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SPINORS[1]

By Professor OSWALD VEBLEN

THE INSTITUTE FOR ADVANCED STUDY, PRINCETON

THE theory of spinors had its origin in the search for a suitable mathematical tool to use in the extension of the quantum theory to the field of relativity. The quantum mechanics in the form that was given to it by Schroedinger describes the motion of a particle by means of the concept of a wave. It is not, as people used to say, that a physicist thinks of an electron as a particle on Mondays, Wednesdays and Fridays, and as a wave on Tuesdays, Thursdays and Saturdays, and on Sundays prays for a Messiah who will lead him back to the belief which he held on Mondays. The actual situation is quite different from that. He works with a mathematical theory which he visualizes for some purposes by means of the classical conception of a particle and for other purposes by means of the imagery of the wave theory. The wave that he works with is just a function which satisfies a partial differential equation of a certain type. The physicist believes that by applying a certain integration process to the solution of this partial differential equation he is able to express the probability that the particle which he thinks of shall be in a certain preassigned position with a certain preassigned velocity.

The whole thing is an attempt to find mathematical formulas and language for the discussion of phenomena which did not make sense in terms of the language and formulas which the physicist had been using before. Some people actually go so far as to say that we shall have to make real changes in our habits of thought and use of language. But I am referring to these deep and difficult questions only incidentally. I am concerned with something much more superficial.

The spinor theory grew out of the attempt to reconcile the wave mechanics with the relativity theory. The wave mechanics was at first developed so as to fit into the framework of the classical dynamics. On the other hand, the theory of relativity has taken

[1] Fourth of the Joseph Henry Lectures of the Philosophical Society of Washington, presented March 31, 1934, in honor of the first president of the Philosophical Society. This paper was prepared from stenographic notes taken at the time of the lecture.

such a firm hold of all branches of physics that every one is convinced that a really sound theory must take it into account. Therefore, the problem was to find a relativistic formulation of the quantum theory.

Also there was experimental evidence indicating that from the particle point of view an electron should not be considered just as a mathematical point but rather as a thing which is capable of a rotary motion or spin at the same time that it has a motion of translation. The problem of bringing this concept into the theory of the electron turned out to be closely related to the problem of giving a relativistic formulation to the differential equations of the electron.

What looks like a very good solution of the problem was developed by Dirac, building upon previous work of Pauli and others. Dirac modified the Schroedinger differential equation not only by changing its form but by replacing it by a system of four equations with four unknown wave functions, ψ^1, ψ^2, ψ^3, ψ^4. These four functions were related among themselves in what seemed to be a very intricate manner, but they were evidently the components of a physical quantity of some sort.

When I speak of a physical quantity I am thinking of something which has components analogous to the components of a vector. When you take the three rectangular components of a velocity you recognize that you are taking components of something which has a physical existence. In the same way, the quantities which appeared in the Dirac equation were evidently components of some sort of a physical object. But they behaved quite differently from the components of any previously known physical quantity and thus provided a puzzle for the mathematical physicist.

The problem was clearly formulated by the late Professor Ehrenfest. He said, in effect: We are familiar with such things as vectors which are the tools of classical physics. Since the advent of the relativity theory we have got acquainted with the theory of tensors and have been led to believe that any physical phenomena could be described by means of tensors. Now comes a new kind of a physical quantity which is not a tensor and yet has to be taken into account. It has something to do with a spinning electron. Let us call it a *spinor*. Then he called on the mathematicians to provide a theory of spinors, if possible, analogous to the theory of tensors.

The elements of such a theory were in fact already available in Dirac's own work and in the previous work of Darwin and Pauli. The Dirac equation had also been adequately discussed from the point of view of the underlying group theory by Weyl in his book on group theory and quantum mechanics, so that implicitly a good deal of the requisite theory was in existence. Nevertheless, so long as it was possible for a mathematical physicist of the order of magnitude of Ehrenfest to regard it as obscure there remained something of a problem.

Promptly in response to Ehrenfest's challenge, a formal theory of spinors was produced by van der Waerden. This was a theory of two-component spinors which was adequate to the Dirac equation in its original form. But here one has to say, as in so many other cases, that a fully satisfactory account of the subject was possible only after the original theory had been highly generalized. It was in fact so in this case. The original Dirac equation was relevant to the special relativity. The extension to general relativity was indicated first by Weyl and Fock and the system of mathematical equations thus determined has been studied by Schouten, Schroedinger, Einstein and Mayer, and other mathematical physicists. From these studies there has now emerged a clear conception of a class of physical objects which we call spinors and which can be precisely defined.

I shall try to state this definition. In doing so I propose to repeat a number of well-known elementary ideas leading up to the one step which introduces the definition. After this is done the whole matter may seem rather trivial, but it is nevertheless true that after this foundation is laid the working out of the theory becomes a matter of technical detail.

We start with elementary geometry. How are the points in a room to be described? The first step in such a description is to give names to the points so as to distinguish them, and we agree to use numbers as names. A point will have a first name x, a second name y and a third name z. The way which we all know for assigning these names is to let x be the distance of the point from the floor, y the distance from the wall at the front of the room, and z the distance from one side wall. That way of assigning the names is of course completely arbitrary. It could be done in some perfectly bizarre way so long as you satisfied the condition of giving different names to different points. A system of naming the points is what we call a coordinate system.

I have mentioned a particular way of naming the points only to emphasize the fact that the particular system we use for assigning these names is of no importance. We can, in fact, when we have one way of naming them, get any number of other ways by the following device. Suppose you write down these three equations:

$$\begin{aligned} X &= x + y \\ Y &= x - y \\ Z &= z^2. \end{aligned} \tag{1}$$

If we substitute in these equations the numbers x, y

and z appearing in the name of this point, we get three other numbers (X, Y, Z) which gives us a new name for the point, and so we have a new coordinate system. These equations can be solved to give

$$\begin{aligned} x &= \tfrac{1}{2}(X+Y) \\ y &= \tfrac{1}{2}(X-Y) \\ z &= \sqrt{Z}. \end{aligned} \qquad (2)$$

If we apply these equations to any point in the room and know the names X, Y, Z, we are able to get back the names x, y, z. We have a dictionary which translates one system of nomenclature for our points into another system of nomenclature. This dictionary is what we call a transformation of coordinates.

In general, a transformation of coordinates

$$(x, y, z) \rightarrow (X, Y, Z)$$

is defined if we replace the right-hand members of equations (1) by quite arbitrary functions subject only to the condition that (1) should be capable of being solved so as to obtain the inverse transformation

$$(X, Y, Z) \rightarrow (x, y, z)$$

analogous to (2). In all this we confine attention to points in the room, that is to say, to a limited portion of space. In practice we require that the functions used shall be amenable to the processes of analysis, such as differentiation, etc., corresponding to the technique of the mathematician of the present epoch.

The essential point which I should like to stress in this consideration of coordinate systems and transformations of coordinates is that the coordinate system is something which we ourselves introduce. It is something in addition to the physical state that we are trying to describe and represents our point of view towards the natural phenomena which are under consideration. To be objective, we must somehow or other get away from this thing that we have introduced. In previous generations mathematicians and physicists used to play with the idea of doing without coordinates. The geometry of Euclid is an example in which coordinates were not used and the attempt was made to reason directly with the physical objects we were talking about. Many will recall the time when it was regarded as important to do vector analysis without coordinates. This idea was based on the feeling that by so doing one was dealing with the natural object itself.

An equally good way of being free from the influence of the coordinates introduced is to use all coordinate systems. Using no coordinate system is, so to speak, the dual idea to using all possible coordinate systems. If you arrange your work in such a way that it applies no matter what the coordinate system is, then you have reached the ideal of dealing with the object itself. This point of view has become very common since the discussions which were brought about by the theory of relativity.

In dealing with physical problems much use is made of vectors. A vector is a special case of what we can call a physical object with components. The idea is something like this: Supposing that in a room we have at every point a tendency of a certain sort, no matter what sort, but a tendency in a definite direction with a definite magnitude. That tendency can be defined by associating with each point (x, y, z) three numbers V^1, V^2, V^3.

$$V^1(x, y, z) \quad V^2(x, y, z) \quad V^3(x, y, z).$$

They describe this tendency and they are the components of something that represents a physical state of affairs. If this physical object is a vector, then on making a transformation into a new coordinate system you will get functions

$$\overline{V}^1(\bar{x}, \bar{y}, \bar{z}) \quad \overline{V}^2(\bar{x}, \bar{y}, \bar{z}) \quad \overline{V}^3(\bar{x}, \bar{y}, \bar{z})$$

of the coordinates $\bar{x}, \bar{y}, \bar{z}$. When you measure this physical object in the new coordinate system, you will get the new set of quantities $\overline{V}^1, \overline{V}^2, \overline{V}^3$, and there will be definite formulas which tell you what these components in the new coordinate system are:

$$\overline{V^1} = f^1(V^1, V^2, V^3) \quad \overline{V^2} = f^2(V^1, V^2, V^3) \quad \overline{V^3} = f^3(V^1, V^2, V^3).$$

You will have three formulas of this sort which express the new components as functions of the old ones. There is no need of my mentioning what these formulas are in detail, for in talking about a subject which is full of formulas, we should be hopelessly lost if we got tangled up with particular formulas. The essential point which I want to bring out is that when you change to a new coordinate system you get a new set of components and in every coordinate system there is a set of components for the physical object. If the law which tells you the new components in terms of the old components is of a particularly simple sort, then your physical object is a vector. There are lots of other physical objects. For example, there are physical objects with 9 components that you could call T_{11}, T_{12}, T_{13}, etc., using two indices. Then if you have a certain formula connecting the components in one coordinate system with those in another, the thing you are talking about is a tensor of the second order. The essential things about a tensor are that it is a physical object with components, and that the components are uniquely determined when the coordinate system is given in terms of which the components are described. I am intentionally leaving this statement in a thoroughly abstract form.

When we come to the theory of relativity we must pass from the three-dimensional space of points to the four-dimensional world of events. This is a story which you probably have heard many times. If you want to describe the events which take place in this room, you have to give not merely x, y and z, which tell you *where*, but also t, which tells you *when*, for each event. The essential point is that the events we talk about are things which are capable of being named by means of four names, the four names being numbers. This can be expressed by saying that the events constitute a four-dimensional world or space-time.

Let us transfer what we have just been saying about coordinate systems from the world of points over to the world of events. We make the same remark that we made before. The essential thing about a coordinate system for events is not any particular way of setting up the coordinate system but is the fact that the coordinate system assigns distinct names to different events.

In order to make an objective description of the world of events, we deal with the totality of coordinate systems. We keep free from any particular point of view and so talk about all coordinate systems at once. For this purpose we have a complete theory of transformations of coordinates and a theory of vectors and tensors. A tensor is a physical object such that with every event we are able to associate a set of numbers called its components when we have before us a given coordinate system. If we change to a new coordinate system we get a new set of components of the same physical object.

Thus in the general relativity theory itself we have a set of 16 functions

$$g_{11}(x^1x^2x^3x^4), \quad g_{12}(x^1x^2x^3x^4), \cdots, \quad g_{44}(x^1x^2x^3x^4).$$

These functions of the coordinates are the components of a physical object called the fundamental gravitational tensor. They satisfy a system of partial differential equations, and the theory of these equations is the relativity theory. The general conception is this: We assume that a given body of physical phenomena is representable by a physical object with components of a certain type, and the theory of these phenomena is contained in the set of differential equations which the components satisfy. This, without any formalism, is the basic mathematical idea which appears in the relativity theory.

Continuing in that theory, it turns out that there are certain other kinds of geometrical objects which have to be considered. The ones which appear first are the electromagnetic potentials. Again there are four components

$$\phi_1, \phi_2, \phi_3, \phi_4$$

which are functions of the coordinates. But, as physicists know, when you give the coordinate system the electromagnetic potentials are not fully determined. You can take another function $f(x^1, x^2, x^3, x^4)$ and add the four derivatives of this function to the components, obtaining

$$\phi_1 + \frac{\partial f}{\partial x^1}, \quad \phi_2 + \frac{\partial f}{\partial x^2}, \quad \phi_3 + \frac{\partial f}{\partial x^3}, \quad \phi_4 + \frac{\partial f}{\partial x^4}$$

without changing the physical significance of these potentials.

Let us try to say what is essential in this without using technical language. It ought to be clear even to those who do not know what these differentiation symbols mean. When we specify a definite coordinate system we have not only one set of four functions which appear as the components of our physical object, but we have a whole class of other sets of components. The physical object in question is of an essentially different kind from those which we have previously been talking about. Its components are not fully determined when the coordinate system is given; something in addition has to be specified before the components are known. This additional something which we have to specify we will call a gauge frame.

I might also try to put it in the following way: We previously said that when we introduce a coordinate system we put something into the phenomena of nature, and before we can be talking about nature itself we have to get free of the coordinate system which we put in. When we talk about electromagnetic potentials, we put something else in, namely, the gauge frame, which has to be specified before we can specify the particular set of components which we are talking about.

So our theory has to be such that we make not only transformations of coordinates but transformations of gauge, and we have to formulate our laws of physical phenomena in a manner which is unaltered not only by changes of coordinate system but also by changes of gauge. Physicists have heard a good deal about that under the heading of gauge invariance. The underlying idea is just as before: In trying to describe nature we have introduced not only coordinate systems, but also another extraneous element called the gauge frame. In addition to the theory of coordinate transformations, there is a theory of gauge transformations which has to be recognized in order to free our theory of physical phenomena from this element which we introduced in our view of nature.

The theory of spinors requires another step in this direction. A spinor is a physical object with components. The number of components is a power of four. In a particular case a spinor may have four

components $\psi_1, \psi_2, \psi_3, \psi_4$. The components are functions of the coordinates just as the ϕ's and g's were, but when the coordinate system and the gauge frame are given, the components of the spinor are not fully determined. You can take a new set of components $\bar{\psi}_1, \bar{\psi}_2, \bar{\psi}_3, \bar{\psi}_4$, which will serve equally well as a set of components of this spinor. The new components are given by means of linear formulas in terms of the old components.

$$\bar{\psi}_1 = T^1_1\psi_1 + T^2_1\psi_2 + T^3_1\psi_3 + T^4_1\psi_4;$$

and three other formulas which look like this one. The coefficients T are arbitrary functions. A linear transformation of this sort is called a spin transformation.

When you have given your coordinates and your gauge, there is still something free, which we will call the spin frame, and we are unable to describe our physical object until the spin frame is fixed. We have to state everything that we say about a spinor so that it will be true no matter what spin transformation is applied to the components. A spin transformation is very analogous to a coordinate transformation, but it takes place completely independently of the coordinate transformation.

This is the simplest example of a spinor. There are spinors with 16 components or in general with 4^k components and you will have linear formulas which give you the other possible sets of components in the same coordinate system.

I have not yet mentioned one of the important facts about spinors which give them their significance. Their components are not ordinary numbers. They are complex numbers of the form

$$a + \sqrt{-1}\, b$$

where a and b are real numbers. In this respect they are like other physical objects which appear in quantum theory. There have been cases in physics before where the complex numbers were used as a convenient device but here they come in an essential way.

The additional degrees of complication which appear in the definition of a spinor correspond to the nature of the physical problem which it is designed to meet. Ordinary vectors and tensors would be well enough adapted to tell where an electron is, in what direction it is going, and what its angular momentum is. But the quantum theory states the problem differently. It does not ask directly what these quantities are but rather, what are the probabilities that these quantities shall take on preassigned values. To meet this requirement, it is not the components of the spinors themselves which are interpreted in terms of physical measurements, but certain combinations of these components with their complex conjugates. These combinations of components of spinors are components of ordinary tensors and are interpreted as probabilities that the electron will be in a certain place moving in a certain way.

Let us now repeat the description of a spinor in a few words. A spinor is a physical object which has components which are complex functions of the coordinates. The number of components is a power of four. A set of components is fixed only after (1) the coordinate system, (2) the gauge-frame and (3) the spin frame, are fixed. Whenever (1), (2) or (3) are changed, the components are replaced by linear combinations of themselves according to definite rules.

Suppose that you have spinors with 16 components with two indices, X_{AB}, and suppose that these spinors satisfy the condition that

$$X_{AB} = -X_{BA}, \tag{3}$$

so that they are antisymmetric. Then the mathematicians will recognize that connected with them there is a quadratic expression

$$X_{12}X_{34} + X_{13}X_{42} + X_{14}X_{23} = 0. \tag{4}$$

Those spinors which satisfy this relation have peculiar properties, and it is this quadratic relation which puts the spinors into connection with the fundamental tensor of the relativity theory, because the g's that we have in relativity are also the coefficients of a quadratic expression.

If you are going to describe some particular physical phenomena such as those described by the relativistic theory of the spinning electron, you must pick out one or more particular spinors which embody the physical phenomena in question. It turns out in this special case that you can pick spinors which set up a suitable relationship between the quadratic equation (4) above and the fundamental quadratic form which appears in the relativity theory. The general theory of spinors is the theory of all possible physical quantities of a certain sort. The theory of the electron is the theory of certain particular spinors which describe this electron.

OBITUARY

FRANK LINCOLN STEVENS

WITH the death, on August 16, of Professor F. L. Stevens botanical science has lost one of its most devoted and productive workers; and many younger botanists mourn the loss of his kindly advice and encouragement.

He was born at Syracuse, New York, on April 1, 1871, the only son of H. B. and Helen C. Stevens.

He was graduated from Hobart College with the bachelor of law degree in 1891. From Rutgers he received the B.S. degree in 1893 and M.S. in 1897. During the period from 1893 to 1897 he was instructor in science in Racine and in high schools in the state of Ohio. For two years, 1898 to 1900, he served as sanitary analyst for the Chicago Drainage Canal Commission. At the same time he studied in the graduate school of Chicago University, receiving the Ph.D. degree in 1900. He was then granted a traveling fellowship and spent a year studying at various European laboratories—with Strasburger at Bonn, with Klebs at Halle, and for some time occupied the Smithsonian Institution Table at Naples. Upon his return he was appointed instructor in biology at North Carolina State College.

His ability as a teacher was at once so evident that he was appointed professor of botany and vegetable pathology the following year. In this position he taught general botany, plant physiology, plant pathology and bacteriology. His lectures in all these subjects were scholarly and presented in a manner to catch and hold the interest of students without resorting to anecdotes or other subterfuges so common in college classrooms. Several years after he left the North Carolina State College Dr. D. H. Hill, its former president, remarked that Dr. Stevens was undoubtedly the best teacher with whom he had ever come in contact.

Even with this unusually heavy load of teaching he found time to do considerable research personally and to direct research in plant pathology and in soil bacteriology for the experiment station, developing original methods and making notable contributions in both fields.

It was during this period that I first came under the influence of Dr. Stevens's great enthusiasm for research. I immediately planned my course of study so as to spend all the time possible in his laboratories, and have enjoyed his helpful advice throughout the subsequent years.

In 1912 he was elected dean of the College of Agriculture, University of Porto Rico, where he served two years, returning to the States in 1914 as professor of plant pathology at the University of Illinois, where he remained until the time of his death, exactly 20 years.

While in Porto Rico he became interested in tropical fungi, especially in the Meliolineae, and some of his most notable contributions have resulted from studies in this group of fungi. He made several collecting trips to various tropical countries in furtherance of these studies and devoted much time to collection and study of fungi while serving as visiting professor at the University of the Philippines during 1930–31.

However, this specialized field was not sufficient to monopolize his interest and phenomenal energy. During the 20 years at Urbana he has continued research in mycology and general plant pathology. Among other notable contributions made during this period may be mentioned the classical works on the Helminthosporium footrot of wheat and on the effect of ultra-violet light upon fungi.

He published numerous professional papers in the fields of soil bacteriology, mycology, and plant pathology; and was author or joint author of several textbooks for elementary schools, including "Agriculture for Beginners," the Hill "Readers" and "Practical Arithmetic"; and was author of "Diseases of Economic Plants," "Plant Disease Fungi," and "Fungi Which Cause Plant Diseases." The last three are probably the most generally useful books on plant pathology yet presented in the English language.

Dr. Stevens was active in the organization of the American Phytopathological Society and was made president of the society in its second year, 1910. He was also a member of the Sigma Xi and Phi Beta Kappa honor societies and of several professional societies.

In 1925 he received the honorary Sc.D. degree from San Marcos University, Peru, and in 1931 the honorary LL.D. degree from the University of Glasgow.

Among his associates Dr. Stevens was often pointed out as an example of that rare combination of excellent teacher and unusual ability in research. His keen sense of right and his firm but calm and kindly spirit endeared him to all who worked with him.

B. B. HIGGINS

GEORGIA EXPERIMENT STATION

RECENT DEATHS

DR. ELMER ELLSWORTH BROWN, from 1911 until his retirement as chancellor emeritus in 1933 chancellor of New York University, previously U. S. Commissioner of Education and professor of education in the University of California, died on November 3 at the age of seventy-three years.

DR. JAMES CORNELIUS WILSON, professor emeritus of clinical medicine at Jefferson Medical College, Philadelphia, died on October 28. Dr. Wilson was eighty-eight years old.

DR. PHILIPP FISCHELIS, professor of histology, embryology and general pathology at the Temple University School of Dentistry, died on October 30. He was seventy-six years old.

COLONEL BAILEY KELLY ASHFORD, of the United States Medical Corps, known for his work on hookworm carried out under the auspices of the Puerto

Rico Anemia Commission, died on November 1, aged sixty-one years.

DR. LUCILE B. WHITCHER, associate professor of organic and physiological chemistry at Skidmore College, died on October 16 at the age of thirty-seven years. She had been at Skidmore College for eleven years.

SCIENTIFIC EVENTS

THE NEW BUILDING FOR ZOOLOGY AT THE UNIVERSITY OF CAMBRIDGE

A CORRESPONDENT of the London *Times* writes: "The old zoological lecture rooms and laboratories, familiar to generations of students of medicine and natural sciences at Cambridge, have ceased to function. They had served their purpose, in some cases from the days of Newton and Francis Balfour, but became no longer adaptable to current demands. If zoology was to grow with the times new buildings, extra endowment and more staff were needed. The means for fulfilling such aspirations were ultimately made available through the generosity of the Rockefeller Trustees, aided by state and private benefactions, and this afternoon the new zoology building, erected at a cost of £80,000 under a committee with the University Treasurer (Mr. T. Knox-Shaw) as chairman will be open for inspection."

The building, as described in the *Times*, is an L-shaped structure of steel and concrete, and for the most part faced with brick. With a frontage on Downing Street and Corn Exchange Street, it measures 292 feet long, with a breadth of 43 feet. The architect has designed a building of a strictly utilitarian type combined with a certain grace of line and proportion. In some ways it resembles the best type of modern factory construction, the narrow pillars in the walls being 6½ feet apart; except for these, the walls above bench level are entirely of windows, thus providing the maximum amount of natural lighting. Adaptability to possible future requirements is a special feature in the planning; the walls between adjacent rooms are easily removable, while the furniture is of uniform design, allowing the maximum interchangeability.

The building consists of a basement and four floors. In the basement are heating and service supplies, together with rooms for marine and freshwater aquaria. There are also four differentially heated constant-temperature rooms. The ground floor is given over to elementary teaching: it contains a well-designed lecture theater, with seating for over 200 students, and, close at hand, an exceptionally large and well-appointed elementary laboratory. The first floor contains an advanced laboratory and lecture room, the professor's room, and general offices, a staff room, and private rooms for 12 research workers, together with the departmental library.

The whole of the second floor is given over to experimental zoology, which has a large teaching laboratory and 14 rooms available for research. Each room is provided with water, gas, direct and alternating current, and compressed air. Complete provision is made for keeping animals under suitable environmental conditions; there are also several dark rooms, a chemical laboratory, and well-fitted workshops. The chief rooms are provided with means for maintaining them at a steady temperature, often below that of the main building. The third floor is given over to entomology, with rooms for the staff and nine other workers. A large incubator room for studying the effects of temperature and humidity on insect growth is provided. There is also a room for other types of experimental work, an aquarium room, dark room, stores and a small workshop.

The Rockefeller scheme also provided for an entomological field station, which has been erected on the University Farm. It includes laboratory accommodation for advanced students, differentially heated insect houses and out-of-door rearing houses. Adjoining these buildings is an area of about two acres of experimental ground, affording ample means for observing insects under natural conditions.

The Department of Zoology, as rebuilt and reorganized, provides full provision for all grades of teaching and complete facilities for research. There are places for 60 post-graduate workers (including the staff), and 58 have come into occupation. The reorganization planned by Professor Stanley Gardiner has been rendered possible owing to considerable allocations being made for income purposes. This has enabled provision to be made for the upkeep of the subdepartments of entomology and experimental zoology and for the necessary additional staff.

A PROFILE OF SHOAL WATER DEPTHS BY ECHO SOUNDING

CAPTAIN R. S. PATTON, director of the U. S. Coast and Geodetic Survey, has announced a recent improvement in the apparatus to obtain depths by echo sounding. The equipment, now being used in surveys off the Virginia coast, takes 20 soundings a second in depths from 6 to 120 feet, with an accuracy of about one inch. At a cruising speed of ten miles per hour, a sounding is therefore obtained every ten inches along the bottom.

This instrument, known as the "Shoal Fathometer," is a further development of the deep water fathom-

eter, an invention of a commercial company, which has been used by the Coast and Geodetic Survey in hydrographic surveying for over nine years. The deep water fathometer has been of great value for depths of about 15 fathoms (90 feet) to 3,000 fathoms (18,000 feet), the deepest water so far surveyed by the bureau. Not built primarily for surveying, a small variation in depth indication was found to obtain in the apparatus. Having a nearly constant value, this produces a larger percentage of error in shallow water than in water of greater depths. After using the deep water fathometer for nearly a decade as a surveying instrument, the shoal fathometer was developed for the required accuracy for the shallow depths ordinarily covered by means of leadline sounding.

The general method of measuring depths by all fathometers is to produce a sound in the water at the bottom of the ship. This sound travels to the bottom and returns as an echo, picked up by a hydrophone, or electrical ear, in the bottom of the vessel. The fathometer measures precisely, and translates automatically into depth, the elapsed time from the sound production to the return of the echo, and indicates this depth by means of a neon-tube flash on a rotating disc graduated in fathoms. In the shoal fathometer, supersonic frequencies are used for the sound production; that is, a note produced electrically, too shrill for the human ear to detect.

Since sound in sea water has a velocity of about 4,800 feet per second, some idea may be had of the accuracy of the time element in this newly developed instrument, which must measure the elapsed time for the sound to travel, for example, a depth of 12 feet to the bottom and return, a total distance of but 24 feet, requiring only five one-thousandth of a second for the round trip. As the instrument is designed to measure this depth within one tenth of a foot, its accuracy of measurement of time elapsed must be within four one-hundred-thousandth of a second.

When sounding by the old "handlead" method, at a cruising speed of some 5 knots, say in 10 fathoms (60 feet), it is possible to get one sounding every 30 seconds, for it takes that long to heave the lead and haul it in again. That represents one sounding for every 254 feet. A survey ship equipped with a shoal fathometer can travel twice as fast, securing 20 soundings every second. As this represents one sounding every ten inches, it furnishes an almost continuous profile of the bottom.

WORK IN PROGRESS AT THE WISTAR INSTITUTE OF ANATOMY

AT the regular October meeting of the Board of Managers of the Wistar Institute of Anatomy the director in his report described as follows the research work in progress at the Philadelphia laboratories and of the six laboratory guests of the Morris Biological Farm:

Dr. Donaldson is engaged in a study of the growth of the eye under normal conditions—the eye is characteristic of the strain; on the senescence of the nervous system; on the changes in the mutant albino from Dr. King's colony and, in collaboration with Dr. King, on a study of the effects of captivity on the wild gray rat.

Dr. King is continuing her work on the genetics of the rat, including mutations and with special reference to the effects of captivity on growth, fertility, longevity and sex ratio.

Dr. Coghill has resumed his work on the growth of the sensory nervous system by the quantitative method of counting the nerve cells in the spinal ganglia and correlating the facts with physiological function.

Dr. Angulo is working on the embryological differentiation of the nervous system in relation to the increase of physiological activity.

In addition to members of the institute's staff regularly engaged in scientific work at the Morris Biological Farm there were present during all or a portion of the summer the following laboratory guests:

Dr. Edward L. Corey, assistant professor of physiology, University of Virginia. Dr. Corey made a detailed study of the foetal heart of the albino rat by analysis of kymographic records. Records of more than 200 rat foetuses were made and forty-one young rats were recorded under various experimental conditions.

Dr. Arnold A. Zimmermann, assistant professor of anatomy, University of Illinois, College of Medicine, devoted his attention to the development of the lymphatics in the opossum. He was able to examine some thirty series of sectioned opossum embryos and found on the eleventh day of gestation the most important part of the developmental history of the lymphatics.

Dr. O. Larsell, professor of anatomy at the Medical School of the University of Oregon, completed his study of the cerebellum of the opossum. Dr. Larsell followed the growth of the cerebellum from the earliest recognizable stage to the adult form. He found the opossum brain at birth typically reptilian.

Cooperating with Dr. McCrady experimental studies were made on pouch young to determine when and what part of the vestibular portion of the ear first begins to function.

Dr. G. Mackmull, formerly instructor in histology and embryology, Jefferson Medical College, is making a study of the absorption of carbon by body tissues when implanted in capsules or injected into the body cavity of the axolotl.

Dr. A. R. Moore, professor of general physiology, University of Oregon, and lecturer in general physiology at the Hopkins Marine Station, California, was engaged in a study of the physical constitution of plasmodium. In cooperation with Dr. Larsell, Dr. Moore was also engaged in a study of the modification of structure and function of living nerve elements following centrifugation with the ultra-centrifuge.

THE MUSEUM OF SCIENCE AND INDUSTRY AND THE CENTURY OF PROGRESS EXPOSITION

THE Museum of Science and Industry at Chicago, according to the *Museum News*, will receive many important exhibits from the Century of Progress Exposition, which closed on October 31. From the Hall of Science at least 170 separate exhibits in the fields of physics, chemistry, biology, geology, medicine, engineering and astronomy will be transferred to the museum. Historical material in the sciences includes a diorama of Benjamin Franklin's kite experiment; replicas furnished by the Government of Italy of instruments used by Marconi in early transatlantic wireless experiments, of one of Galileo's telescopes, of the first alternating current generator designed by Pacinotti in 1865 and of Nobili's galvanometer, and a large group of exhibits furnished by the Government of Denmark.

In the field of chemistry probably the most important exhibit obtained is the periodic table of the elements from the Hall of Science. All the ninety-two elements are shown in this exhibit, to which six universities, Ward's Natural Science Establishment, the Memorial Hospital in New York and more than thirty commercial organizations contributed. The chemistry of petroleum is shown in a group of exhibits contributed by the industry. Other exhibits in chemistry are a diorama of the mining of sulphur and demonstrations of the chemistry of coal tar, chemical changes and processes and colloid chemistry.

In physics the museum obtains demonstrations in molecular motion, in sound and speech, in electromagnetism and in light. A group of exhibits on color and rays demonstrates the three primary colors, the photoelectric cell, helium and radium rays and the principles of television.

In biology models of generalized plant cells show cell division, a group of models illustrates roots and root characteristics and another group shows the origin of beeswax, spermaceti and whale wax, lanolin, paraffin wax, vegetable waxes and the uses of wax.

In geology two groups of exhibits illustrate methods of prospecting and drilling for oil; a generalized model shows an Artesian basin, a source of ground water and a diorama of Indiana sand dunes, with a small moving dune in the foreground, demonstrates how the dunes are shifted by the wind.

The Government of Italy contributes groups of exhibits on engineering and medicine, and the Government of Denmark groups on astronomy, physics and chemistry.

From other buildings, material is contributed by the U. S. Government and several of the states. Also exhibits, largely of commercial origin, are promised from the Electrical Building, Agriculture Building, Home Planning Hall, Social Science Hall, Colonial Village, Southern Cypress House and the buildings of Sears-Roebuck, T. & T., General Motors, Common Brick Association, American Radiator, Ford, General Houses, Lumber Association and Wings of a Century. Altogether the museum will receive more than 230 exhibits and groups of exhibits from the fair.

THE PITTSBURGH MEETING OF MATHEMATICIANS

THE nineteenth annual meeting of the Mathematical Association of America will be held under the presidency of Professor Arnold Dresden, of Swarthmore College, at Pittsburgh, Pennsylvania, on Saturday, Monday and Tuesday, December 29 and 31, 1934, and January 1, 1935, in affiliation with the American Mathematical Society and the American Association for the Advancement of Science. The meetings will be held in the Administration Building of the Carnegie Institute of Technology.

At a joint session of the three organizations on Monday morning Professor C. N. Moore as retiring chairman of Section A will deliver an address on "Mathematics and Science" and Professor Arnold Dresden as retiring president of the Mathematical Association will speak on "A Program for Mathematics."

A significant feature of the week will be a joint session of the association with the National Council of Teachers of Mathematics on Saturday afternoon at which Professor W. L. Hart, representing the association, and Professor P. W. Hutson and Dr. M. L. Hartung, representing the National Council, will discuss "The Need for a Reorientation of Mathematics in the Secondary Schools." Separate sessions of the National Council will also be held on Friday evening and Saturday morning.

Sessions of the Mathematical Association will be held on Monday afternoon and Tuesday morning. The Monday session will be devoted to a symposium (of non-advanced character) on "Equipotential Loci of Green's Function," led by Professor J. L. Walsh, with the assistance of Professors Morris Marden and J. J. Gergen. At the Tuesday session Professor A. A. Bennett will speak on "The Cubic Equation and the Geometry of the Triangle"; Professor T. R. Hollcroft on "Linear Systems of Algebraic Surfaces," and Professor R. L. Jeffery on "Productive Scholarship in the Undergraduate College." The annual business meeting and election of officers will be held at the close of the session Monday afternoon. The complete program will be mailed to members early in December, as usual.

The Mathematical Society will hold regular sessions on Thursday, Friday and Saturday in the Administration Building. Professor A. B. Coble will deliver his

retiring presidential address. The eleventh Josiah Willard Gibbs Lecture will be given by Professor Albert Einstein. The second award of the Cole Prize in Algebra will be made at this meeting. A special feature of the meeting will be a symposium on group theory as applied to quantum mechanics, at a joint session with the American Physical Society on Saturday afternoon.

The joint dinner of the mathematicians is planned for Saturday evening at the Hotel Webster Hall, the price being $1.50 per plate. Special entertainment is being arranged for Sunday afternoon. In the evening there will be a concert in the Carnegie Music Hall, consisting of organ and symphony orchestra music. Headquarters will be at the Hotel Webster Hall, about half a mile from the Carnegie Institute of Technology and about three miles from the center of the city.

MEETING OF SCIENCE TEACHERS WITH THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

AT the Science Teachers' Meeting held in Boston in December, 1933, in connection with the meetings of the American Association for the Advancement of Science, it was requested that another full day's program be organized for this year. This program will be presented in the Pittsburgh Athletic Association Building on Saturday, December 29. Invitation to participate is extended to delegates from science teachers' organizations and to individual teachers of science from elementary and high schools, colleges, universities and state administrations. The Pittsburgh Athletic Association, where this meeting will be held, is near the buildings in which occur the other meetings of the American Association for the Advancement of Science.

The program will be opened by Professor Otis W. Caldwell, chairman of the Committee on the Place of Science in Education of the American Association for the Advancement of Science, who will speak briefly on the purpose of the meeting. The subject of the morning session will be "Newer Knowledge of Interest to Science Teachers," when papers will be presented on "The Influence of Certain Gases upon Plants," by Dr. P. W. Zimmerman, assistant director, Boyce Thompson Institute for Plant Research; on "Research in Sound and Communication," by Dr. Harvey Fletcher, Research Laboratories, Bell Telephone Company, and on the "Present Status of Knowledge of Cosmic Rays," by Professor Robert A. Millikan, Norman Bridge Laboratories, Pasadena, California. Each paper will be followed by a discussion from an invited speaker. In the afternoon a program has been arranged by the special committee appointed at the Boston meeting on "A National Organization of Science Teachers."

At the luncheon Professor Edward L. Thorndike, president of the American Association for the Advancement of Science, will make an address on "The Psychology of Attitudes," after which scientific men who are invited guests will be presented.

Reservations for the luncheon, which will be served at noon at the cost of $1, should be sent to the local chairman, Dr. John A. Hollinger, Administration Building, Bellefield Avenue at Forbes, Pittsburgh, Pa. The final program, giving the names of the speakers, will be sent on application to the Committee on the Place of Science in Education, 433 West 123rd Street, New York, N. Y.

SCIENTIFIC NOTES AND NEWS

THE Perkin Medal for 1935 has been awarded by the American section of the Society of Chemical Industry to Dr. George O. Curme, Jr., vice-president of the Carbide and Carbon Chemicals Corporation, for his "distinguished research in the field of organic synthesis which has led to the founding of a new industry."

THE Hanbury memorial gold medal of the Pharmaceutical Society of Great Britain has been awarded to Dr. George Barger, professor of chemistry in relation to medicine at the University of Edinburgh. This medal is for "high excellence in the prosecution or promotion of original research in chemistry and the natural history of drugs."

THE Beal Medal of the American Gas Association was presented at the recent convention at Atlantic City to W. H. Fulweiler, chemical engineer of the United Gas Improvement Company.

PROFESSOR RALPH H. MCKEE, of the department of chemical engineering of Columbia University, has received the Commander's Cross of the Polonia Restituta Order of the Republic of Poland in recognition of his services to the Polish Government.

THE Academy of Physical Medicine at the recent New York meeting conferred the title of fellow of the academy upon Dr. Robert Tait McKenzie, physician and sculptor, professor of physical education at the University of Pennsylvania.

AN informal tea for Professor Gilbert D. Harris was given on October 21 in McGraw Hall by members of the faculty of geology at Cornell University and of the two geological societies, Chi Upsilon and Sigma Gamma Epsilon. A correspondent writes: "Professor Harris, who this fall retires from active teaching, plans to continue with the publication of the *Bulletins of American Paleontology* and with the

study of material which he has collected during various geological expeditions made in this country, South America and Europe. Much of this material is at present housed in the recently established Paleontological Research Institution, concerning which Professor Harris spoke briefly. While noting that the institution, with headquarters on Dearborn Place, is quite independent of the university in its organization, Professor Harris emphasized the fact that it is established with the idea of cooperating with the university and of offering its facilities to advanced students, as well as to qualified independent workers who may wish to consult the collection of type specimens and find sympathetic surroundings in which to pursue their own research."

AT Princeton University, Associate Professor Elmer G. Butler has been appointed chairman of the department of biology. After the retirement of Professor Edwin G. Conklin last year Professor Butler served as acting chairman of the department. Dr. Edward Sampson, associate professor of geology, will succeed Professor Alexander Hamilton Phillips as head of the department of geology. Dr. Theodore Dunham, Jr., of the Mount Wilson Observatory, has been appointed associate professor of astronomy, and Solomon Bochner has been appointed to an assistant professorship of mathematics.

DR. HANS RADEMACHER, formerly professor of mathematics at the University of Breslau, has joined the faculty of the University of Pennsylvania for one year under a joint grant from the Emergency Committee in Aid of Displaced German Scholars and the Rockefeller Foundation. Dr. Rademacher served on the faculty at the University of Hamburg before going to Breslau and is known for his research work in the analytic theory of numbers, differential geometry and the theory of functions of a real and complex variable.

ERNEST BASIL VERNEY, Sheild reader in pharmacology and lately professor of pharmacology at University College, London, has been elected to a professorial fellowship at Downing College, Cambridge. Frank Goldby, of Caius College, university demonstrator in anatomy, has been elected to a fellowship at Queen's College.

DR. ERNEST F. FINCH succeeds Professor Graham Simpson in the chair of surgery at the University of Sheffield.

THE Board of Scientific Directors of The Rockefeller Institute for Medical Research announces the following changes in its scientific staff: The promotion of Dr. Walther F. Goebel from associate to associate member and the appointment of Dr. Frank L. Horsfall, Dr. John W. Murray and Dr. Albert B. Sabin as assistants.

The Museum News states that Carlos E. Cummings, acting director of the Buffalo Museum of Science since June, 1931, was appointed director at the annual meeting of the board of managers on October 12. He succeeds Charles J. Fish, who has been on leave from the museum for the past three years and who resigned recently to accept a post at the Rhode Island State College at Kingston.

DR. JOHN W. WILCE has been appointed director of the medical and health service of the Ohio State University. He will hold the rank of professor of medicine in the medical school. Other members of the staff are Drs. Morse F. Osborn, associate professor; James A. Beer, Shirley Armstrong and Charlotte Winnemore, assistant professors, and James M. Foley, instructor.

WILLIAM J. BALDWIN, for eight years connected with the American Radiator Company at Buffalo, has been appointed to an industrial fellowship at the Mellon Institute, the second fellowship provided by the O. Hommel Company for the study of enamel technology.

DR. T. GILBERT PEARSON, executive head of the National Association of Audubon Societies for the last twenty-four years, has retired and has been elected president emeritus. Kermit Roosevelt has been elected president, and John H. Baker, who until now has been chairman of the board of directors, has been named executive director.

DR. JOHN H. WYCKOFF, dean of New York University and Bellevue College of Medicine, has been made president-elect of the American Association of Medical Colleges. He will succeed Dr. Ross V. Patterson, dean of Jefferson Medical College, Philadelphia, who will preside at the meeting to be held in Toronto next year.

DR. D. B. R. JOHNSON, dean of the school of pharmacy at the University of Oklahoma, has been named chairman of the committee on relations of boards and colleges of the American Association of Colleges of Pharmacy.

THE Committee on Scientific Research of the American Medical Association has made a grant of $750 to Dr. Charles H. Frazier, John Rhea Barton professor of surgery, and Dr. James W. Watts, associate in neurosurgery at the Hospital of the University of Pennsylvania, toward a study of the autonomic representation of the urinary bladder in the cerebral cortex and in the hypothalamus. A grant has also been made to James L. O'Leary, of the School of Medicine of Washington University, St. Louis, to assist in financing his studies of the Levén reflexes.

THE American Academy of Arts and Sciences has made a grant for the purchase of scientific equipment

to Dr. Harry R. DeSilva, professor of psychology at the Massachusetts State College, acting upon a recommendation of the Permanent Science Fund Committee. The grant is made to enable Dr. DeSilva to purchase electric supplies needed in the study of relations between metabolism as measured by the gasometric method; body voltage as measured by the D. C. bridge, and body impedance as measured by the A. C. bridge.

DR. WALTER B. CANNON, George Higginson professor of physiology at the Harvard Medical School, has been granted leave of absence from March 15 to September 1, 1935.

DR. GEORGE CANBY ROBINSON, professor of medicine at Cornell Medical College and director of the New York Hospital-Cornell Medical College Association, sailed for Europe on November 3. Beginning on January 1 he will lecture at the Peiping Union Medical College as visiting professor of medicine.

DR. OLIVER L. FASSIG, of the Blue Hill Meteorological Observatory of Harvard University, will return to the School of Tropical Medicine, Puerto Rico, for the winter months to continue his investigations on the climatology of the Caribbean areas. Dr. Fassig will work in collaboration with the members of the staff and Dr. W. W. Coblentz, of the Bureau of Standards, who will be the guest of the school some time during the winter. These investigations are preliminary to the work which is planned in the study of tropical physiology.

DR. WILLIAM BEEBE, director of the department of tropical research of the New York Zoological Park, returned on November 1 from Bermuda, where he has been conducting his deep sea investigations.

DR. GEORGE B. CRESSEY, chairman of the department of geology and geography at Syracuse University, returned on November 1, after an absence of five months in the Orient. Most of the summer was spent in China in studies of land utilization. Dr. Cressey served under appointments from the National Research Council of Washington and the National Agricultural Research Bureau of Nanking.

DR. ALBERT C. SMITH, who spent the past year collecting plants in the Fiji Islands, on a research fellowship from the Bernice P. Bishop Museum in Honolulu and Yale University, has returned to New York and has resumed his work as associate curator at the New York Botanical Garden.

THE delegates from the United States to the ninth Pan-American Sanitary Conference arrived at Buenos Aires on November 1. They are Dr. Hugh S. Cumming, Surgeon General; Dr. Bolivar Jones Lloyd, of the U. S. Public Health Service and the Pan-American Sanitary Bureau, and Dr. Kendall Emerson, consulting physician and managing director of the American Tuberculosis Association and secretary of the American Public Health Association.

DR. PAUL WEATHERWAX, of Indiana University, gave on October 15 the fall dinner meeting address of the Purdue Section of the American Society of Plant Physiologists, at Lafayette, Indiana. He spoke on the subject of "Cornfields of Ancient America."

AT the coming Science Exhibition of the American Association for the Advancement of Science in Pittsburgh, Mellon Institute of Industrial Research will conduct an information booth, at which particulars can readily be obtained regarding the industries and institutions of the Pittsburgh district. Another service of this bureau will be to arrange for inspectional trips, especially through the buildings of Mellon Institute. The committee in charge of the Science Exhibition has very recently selected headquarters for science editors, journalists and newspaper representatives who will be in attendance at the convention. This space has been reserved in the new home of Mellon Institute, where the Science Exhibition will be held. Telegraphic, telephonic and stenographic facilities will be provided.

NEW YORK UNIVERSITY is beneficiary of trust funds amounting to $52,700 and the residuary estate of Dr. William Chittenden Lusk, formerly professor of clinical surgery at the university and Bellevue Hospital Medical College. The fund is in memory of Dr. Lusk's grandfather, Simeon Baldwin Chittenden, a member of Congress from 1874 to 1881, and of his father, Dr. William Thompson Lusk, formerly president of Bellevue Hospital Medical College. The bequests to New York University are for the establishment of the Chittenden Lusk Fund for the advancement of surgical and medical science which will supervise the investigation of causes and cures of disease.

THE Sydney University Biological Society has recently opened, as reported in *Nature*, a field research station at Narrabeen, the erection and fitting of which was accomplished by members of the society and of the Sydney University Rover Scouts; the building contains a workroom, kitchen, verandah and dormitory accommodations, etc. It provides a center for the study in their native habitats of the fauna and flora of sandstone scrub, forest, palm groves, freshwater swamps, lagoons and beaches. The neighborhood is also a sanctuary for native birds. The research work to be done at this station, which is the first of its kind to be founded in Australia, will range from simple individual work to studies by groups of observers, in which botanists, zoologists and geologists may all take part. The new station will also allow biological students to carry out the field work which forms part of their training.

DISCUSSION

PROPOSED TECTONIC MAP OF THE UNITED STATES

FOR several years there has been serious discussion of a plan to make a tectonic map of the United States, on which will be represented all that is known about the major structural units. The committee on tectonics, Division of Geology and Geography, National Research Council, has kept such a plan on its list of desirable projects. Last year one of the guidebooks for the sixteenth International Geological Congress, which met in this country, contained a tectonic map on the scale 1: 10,560,000, with descriptive text.[1] This first attempt has much merit, and has led many geologists to express a wish for a similar map on a larger scale, with correspondingly more detail. In particular it has been suggested that a tectonic map be prepared on the scale 1:2,500,000, which is the scale of the new geologic map of the United States, published in 1933 by the U. S. Geological Survey. The writer, sympathizing strongly with this suggestion, recently accepted the chairmanship of the committee on tectonics in the hope that preparation of such a map may become an immediate project of the committee.

The task of preparing the map will not be an easy one. Cooperation of a large number of geologists in all parts of the country will be a first essential. No small group using only what is now published in geologic literature can hope to produce a tectonic map that is even approximately correct or complete. Knowledge of geologic structure has been growing at a rapid rate within the past few years. A large store of information that has accumulated is not yet published; and many important facts that have been announced can be represented usefully on a map only by those who have first-hand knowledge of the latest field developments in particular areas. Even with the maximum cooperation it will not be possible to make the map nearly complete, because the structure in large areas is little known and will remain so for some time. Probably it will be necessary to leave some blank spaces, and to query some of the relationships that are shown. Inability to make the map perfect, however, is not a good argument for delaying the project. Every map is a report of progress, inviting corrections and additions. By setting down all that is known, we focus attention on the gaps in knowledge and thus give direction and stimulus to further effort.

The need of a good tectonic map, accompanied by explanatory text, is generally acknowledged. At present it is extremely difficult to form an adequate picture of the general structural relations, even in limited areas. Necessary information, if it is available at all, generally is fragmentary and scattered in the literature. For many districts there are contradictory accounts, which can be evaluated only by time-consuming study. A map that shows the principal structural facts in each district, and at the same time gives the most probable interpretation of the facts in their regional setting, not only is a convenient source of information but also serves as a basis for further investigation work. Such a map would be welcomed by scientific and educational institutions, and also by men engaged in exploratory work for petroleum and mining companies.

Opinions differ considerably as to what a tectonic map should attempt to show and as to the most effective technique for expressing particular facts and relationships. The chief purpose of the present article is to state tentative specifications for the proposed map, and to invite all who are interested to offer frank criticisms and constructive suggestions.

There is obvious advantage in having the scale of the map 1: 2,500,000, as this scale makes it possible to show considerable detail, and to make direct comparison with the geologic formations shown on the new map mentioned above. Comparison will be most effective if the tectonic map is printed on transparent paper, to allow direct superposition, like the tectonic map of Europe made to accompany the small geologic map by Beyschlag and Schriel. However, there is much to be said also for printing the map in more durable form on heavy opaque paper, to permit mounting for wall use, or to make an effective worksheet on which geologic units and additional symbols may be entered at will. If both of these forms seem to be popular, it may be possible to print the map in both ways.

It is suggested that the map represent the following features: trend-lines in folded belts, with axes of individual major folds so far as the scale of the map permits; direction and degree of important overturning of folds; cross folds or important changes in pitch of major fold axes; direction and degree of regional dips; all important faults, with appropriate symbols and figures showing, so far as known, direction and degree of dip, amount of throw and nature of displacement—whether normal, reverse or strike-slip; major thrusts (with a special convention or color to designate overthrust masses); belts of *en échelon* faults; important areas of metamorphic rock, with strike and attitude of the cleavage, so far as it can be shown; areas of pre-Cambrian rocks related to orogenic zones, as discussed recently

[1] "An Outline of the Structural Geology of the United States," by Philip B. King. Guidebook 28, XVI International Geological Congress. Government Printing Office, Washington, D. C., 1932.

by Bucher[2]; all major igneous masses; swells and basins in areas of unfolded rocks (possibly by structure contours); salt domes and anticlines; monoclinal folds.

Time relationships should be indicated, so far as practicable, by conventional patterns or colors. If conventions are chosen judiciously, they may be superposed in areas that have experienced repeated diastrophism. It may even be feasible to indicate important vertical movements in folded belts, such as the late uplift of the Appalachian region. Considerable ingenuity will be required to represent all the complex disturbances in some western areas, even where adequate information is available. It does not seem practicable to show the geologic dates of individual faults. However, faults that are recognized as "active" can be distinguished from those supposedly "dead"; and it may be desirable to indicate that faults in an important group are essentially contemporaneous. Thrust faults in a belt of folding involve no special problem.

Considering the scale of the map, there is danger of attempting to show too much detail in areas of complicated structure. It is better to present limited information clearly than to have parts of the map overloaded to the point of confusion. The degree of complexity beyond which the law of diminishing returns begins to operate can be determined for each part of the map only by careful experiment. Rigid rules should not be strictly applied to all areas; for example, structure contours may be used with profit in areas that have simple structure, but not in belts of complex folding.

The function of a memoir to accompany the map requires little explanation. Many facts and relationships that can not be represented adequately on the map should nevertheless be made available. Reasons for interpretations given by the map should be stated, and discussion of possible alternatives will be helpful. Numerous cross-sections to show critical structural relations will be invaluable to users of the map. Diagrams and large-scale maps can be used to elucidate the structure in limited key areas. If the memoir is prepared adequately, it will be fully as useful as the tectonic map itself; and the two will be indispensable parts of a unit treatise.

It was suggested recently by R. D. Reed that a tectonic map should be accompanied by a series of paleogeographic maps of a rather special kind, to represent the evolution of major tectonic units. Such maps would show not only the outlines of subsiding and rising areas in various geologic periods, but also thicknesses and important facies of deposits in basins of sedimentation. Symbols could be used to represent facies, and either contours or actual figures or both to indicate thicknesses. Maps of this kind for limited areas have been published. A comprehensive series for each of the major tectonic units in the United States would form a proper and valuable part of the memoir to go with a tectonic map.

The efforts of the committee will be justified only if the result is equipment that can be used to advantage by numerous students of tectonics. Exactly what kind of map do these students require? Specific suggestions offered at an early date, while plans are in the formative stage, will be most useful in furthering the project.

COMMITTEE ON TECTONICS,
CHESTER R. LONGWELL, *Chairman*
DEPARTMENT OF GEOLOGY,
YALE UNIVERSITY

[2] "The Deformation of the Earth's Crust," by Walter H. Bucher. Princeton University Press, 1933.

"THE" SOUTH AND "THE" NORTH

IN a recent number of SCIENCE (September 28, 1934), under Science News, subtitle "Air Conditioning of Hospitals," there is an abstract of a paper from which the public learns that "in acute appendicitis the fatality rate is almost three times as high in the South as in the North"; further, that acute nephritis shows a "high death rate in the South and low death rate in the more stormy North." These assertions are attributed to Professor C. A. Mills, of the University of Cincinnati. They struck me because I am somewhat familiar with living in two places, central Missouri and the southern tip of Florida. I need not point out which is more south and more north by 800 miles.

During the summer just ended, in the "tropical" climatic region of the United States, the temperature rose on three days as high as 93°, confining itself on other summer days to the customary maximum of 90°. To tell the whole truth, however, on one day it reached the terrific (?) climax of 96°. Yet no death from "heat stroke" was reported in the papers, although many aged people live here. During the same weeks and months I received letters from my friends and relatives in Missouri, saying that they were sweltering under afternoon temperatures between 105° and 110°, and that on days when it rose only to 100°, they felt blest. Further, all the year around, it is nothing undreamed of in Missouri to have to stand an average of one day thirty degrees above or below that of the directly preceding day. Eight hundred miles south looking in the records for an analogous event amounting to only ten degrees difference meets with success but rarely.

"Patients should be protected from the heat waves of summer—and the year around from sudden changes in weather." True! But the truth is stultified by translating it into "The South." I assert

that "the" South and "the" North are no concepts of medical science.

MAX F. MEYER

CORAL GABLES, FLA.

A CRITICISM OF THE ARTICLE "ENZYMES, VITAMINS AND THE ZONE OF MAXIMUM COLLOIDALITY"

I FEEL obliged to write in protest against the article, "Enzymes, Vitamins and the Zone of Maximum Colloidality,"[1] by Dr. Jerome Alexander, published in SCIENCE last summer. The article discloses a lack of familiarity with enzymes. Alexander speaks of the possibility of decrease of enzyme activity through too great a degree of aggregation and then says: "On the other hand, too great a degree of dispersion of the enzyme might lead to a particulate kinetic activity so intense that the number of *successful* encounters between enzyme and reactants would be reduced to the level of inefficiency." This is an improbable supposition which has no experimental evidence to support it.

Alexander says that his views regarding the necessity for a maximum zone of colloidality for an enzyme are confirmed by an experiment where pepsin coagulates a suspension of denatured egg-white and where the coagulum is dispersed by adding hydrochloric acid. Here it seems to me that there is no connection between hypothesis and experiment.

He states: "Recent work of Professors Richard Kuhn, Otto Warburg and their collaborators indicates that the newly isolated water-soluble lyochromes, the flavines, which apparently constitute vitamin B_2, exhibit enzymic activity when brought into the colloidal state, presumably by fixation on a colloidal carrier." At the time of publication of Alexander's paper an *in vitro* formation of the yellow oxidation enzyme had not been demonstrated. Shortly afterward appeared a paper by Theorell[2] describing the crystallization of the enzyme, its inactivation through splitting into its pigment and protein components and its partial reformation upon adding the pigment to the protein.

JAMES B. SUMNER

CORNELL UNIVERSITY

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

MINUTES OF THE EXECUTIVE COMMITTEE

THE meeting of the executive committee was held in the office of The Science Press, Grand Central Terminal, New York City, on October 21, 1934, with the following members present: Drs. Cattell, Compton, Conklin, Curtiss, Fox, Livingston, Thorndike, Ward, Wilson and Woods. Dr. Hildebrand was excused for absence.

(1) The minutes of the last meeting, held at Berkeley in June, had been approved by mail.

(2) The financial report of the treasurer was discussed, accepted and ordered audited.

(3) The executive committee expressed its appreciation of the valuable services rendered by the treasurer.

(4) The treasurer's budget was approved as adjusted.

(5) The permanent secretary's financial report was discussed, accepted and ordered audited.

(6) The budget of the permanent secretary's office was approved.

(7) The budget for the Pittsburgh exhibition, prepared by the director of exhibits, was approved.

(8) The permanent secretary's office was authorized to sell surplus copies of the 1929–1934 Summarized Proceedings volume to non-members at $4 per copy in paper cover, and $5 in cloth binding.

(9) The executive committee voted to express to the executive assistant its appreciation for the fine work done on the volume of Summarized Proceedings just issued.

(10) The permanent secretary reported on his conference with the local committee for the forthcoming Minneapolis meeting. The dates of June 24 to 29, 1935, were approved as suggested by the local committee. A Maiben lecture was authorized to be given by a prominent worker in medicine, if feasible. Other topics were suggested for general addresses. The permanent secretary announced that the Minnesota Medical Society would meet in connection with the association at Minneapolis, from June 24 to 26.

(11) The dates of the St. Louis meeting were fixed for December 30, 1935, to January 4, 1936.

(12) The quadrennial convocation of 1936 was definitely scheduled for Washington, D. C.

(13) A brief report was presented on meetings to be held at Rochester (June, 1936), Denver (June, 1937) and Indianapolis (December, 1937).

(14) The permanent secretary was authorized to investigate the matter of extending the list of future meeting places to include 1940. The committee favored especially a summer meeting for 1938 in Canada and the following winter meeting in a southeastern city. This item was made a special order for the Pittsburgh meeting.

(15) The executive committee reaffirmed the recom-

[1] Jerome Alexander, SCIENCE, 80: 79, 1934.

[2] Hugo Theorell, *Biochem. Zeit.*, 272: 155, 1934.

mendation made at the Berkeley meeting that the council adopt the following amendment to the constitution, which was also considered favorably by the council at Berkeley: In Article 2, line 4, omit the words, "The admission fee for members is five dollars; the annual dues are five dollars," and add in their place, "The Council shall fix the admission fees and dues."

(16) A report from the committee on source books in science was read and accepted.

(17) The permanent secretary reported progress for the committee on grants, but no action was taken.

(18) It was recommended to the council that $3,000 for grants be appropriated from treasurer's funds available for appropriation.

(19) A brief report of progress from the committee on adult education was read and accepted.

(20) The permanent secretary presented a report on recent publications of the association, namely, the book on "Nationalism" and the two Occasional Publications issued this year.

(21) A statement from Dr. Duren J. H. Ward summarizing the organization of the Far Reaching Foundation was accepted for record. The permanent secretary was requested to correspond with the secretary of the special committee appointed in 1931, requesting it to continue its work.

(22) Dr. W. A. Noyes was appointed the association's representative in the division of foreign relations of the National Research Council.

(23) A special committee was appointed to study the problems of organization recently raised and to report to the executive committee and council at the Pittsburgh meeting. The chairman appointed as members of the committee Drs. Caldwell (*chairman*), Cattell, Compton, Livingston and Ward.

(24) The committee adjourned to meet in Pittsburgh at 8 P. M., on Wednesday, December 26, 1934, following the committee dinner at 7 o'clock at the Hotel Schenley.

HENRY B. WARD,
Permanent Secretary

SCIENTIFIC APPARATUS AND LABORATORY METHODS

SIMULTANEOUS RECORDS OF EYE-MOVEMENTS AND THE VOICE IN ORAL READING

ALTHOUGH silent reading and oral reading are recognized as being essentially different processes, many clinicians in this field make frequent use of oral reading as a diagnostic tool in the treatment of poor silent reading. Also, recent studies have shown that poor silent readers are also inferior in oral reading and make essentially the same kinds of errors in both silent and oral reading.[1] Phonograph recordings of oral reading show definitely the frequency and nature of these errors, but they fail to indicate how the errors are related to the sensory processes of vision employed in reading. One important phase of these sensory processes is eye-movements. Accordingly, it seems that an apparatus which will record eye-movements and speech simultaneously will make it possible to examine the validity of the former as a diagnostic tool in reading difficulties from an entirely new angle, *i.e.*, in the light of the errors actually made by the reader.

The technique proposed consists of three parts: (a) a standard eye-movement camera,[2] (b) a commercial cutter for recording aluminum disk phonograph records and (c) an oscillograph which photographs the sound wave from the voice on the film which receives the eye-movement record. The oscillograph used for this purpose is a Dorsey Phonelescope[3] with the diaphragm activated by a standard headphone. Although the phonelescope does not record wave-form accurately, it is inexpensive and durable and is thus ideal for the present purpose, where it is desired only to locate the various words and syllables. The reader's voice is picked up by means of a ribbon microphone, amplified and sent into the electrical phonelescope. The ribbon microphone is very suitable in this set-up because it is directional in its sensitivity and this makes it possible to eliminate most of the noise of the eye-movement camera.

A record taken on the apparatus assembled as described is shown in Fig. 1. The letters A, B and C indicate the points on the film at which the eyes begin new lines of print. The numbers 1, 2, 3, etc., show the saccadic movements of the eyes in moving across the page. The small letters a, b and c indicate the beginning of vocalization of the lines which correspond respectively to points A, B and C on the eye-movement record. It will be noticed in this sample passage that the eyes are preceding the voice by approximately one second as well as by two or three saccadic movements. The amount of this "eye-lead," as it might be called, seem to be a definite and constant reading habit and is probably functionally

[1] By "oral reading" is meant vocalizing to oneself rather than reading interpretatively, as if to some one else. The vocalization is simply an exaggeration of the ordinary subvocal speech which is frequently, if not always, present in silent reading.

[2] H. H. Jasper and R. Y. Walker, "The Iowa Eye-movement Camera," SCIENCE, 74: 291–294, 1931.

[3] Sold by C. H. Stoelting, Chicago, Ill.

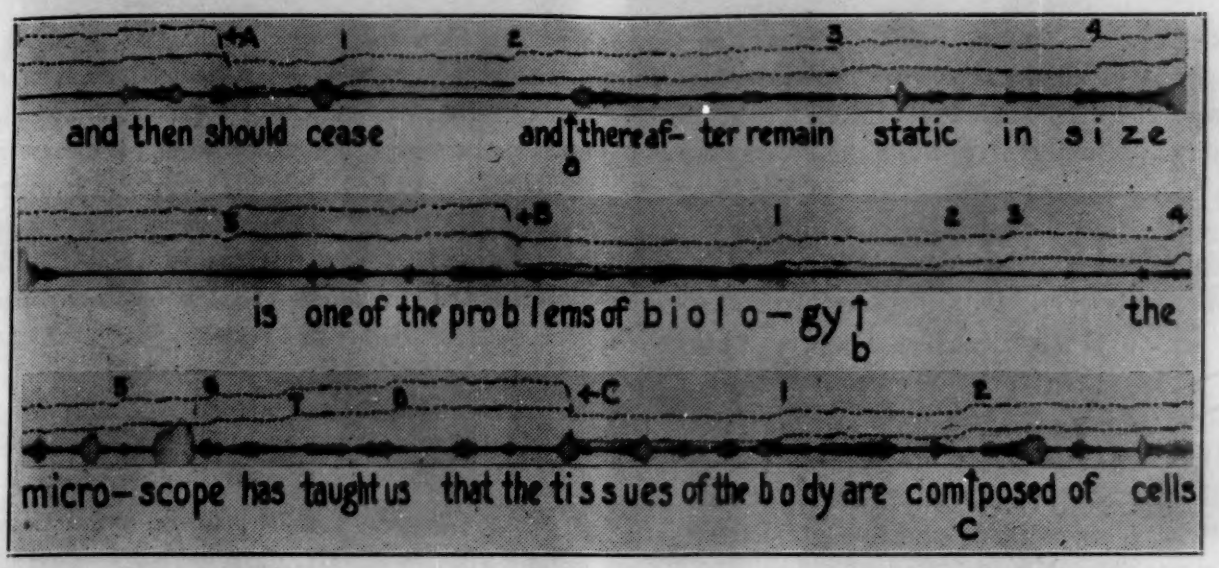
and then should cease
and thereaf- ter remain static in size
is one of the problems of biolo-gy the
micro-scope has taught us that the tissues of the body are composed of cells

FIG. 1.

related to reading ability. It remains for a series of studies now under way to determine the relationship between this variable and other measurable aspects of reading ability.

This note is published at this time because others interested in eye-movement photography may wish to expand the possibilities of the supplementary voice record.

JOSEPH TIFFIN

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UNIVERSITY OF IOWA

SPECIAL ARTICLES

THE WEIGHT OF THE NEGRO BRAIN[1]

BURIED in the older literature of medicine and anthropology, and in the main forgotten, is to be found a great wealth of quantitative material on variation in man, in respect of various anatomical and physiological characteristics. In many cases these data are quite as accurate, critically taken and recorded as those being gathered at the present time. All that they need to be made useful for present-day purposes is to be analyzed biometrically. Furthermore, such forgotten observations often have a special interest for comparative purposes, in that they date from a substantial period of time back of the present, and therefore present the opportunity of judging what degree of secular change, if any, has occurred in the character observed. As new methodologies are discovered and perfected in any branch of science it is often profitable to reexamine and reanalyze old data by the new methods, provided, of course, that the old data are intrinsically sound and critically collected. Nowhere is this more true than in physical anthropology, where the collection of data is at best an extremely expensive and laborious process.[2]

It is an accepted view that the skull capacity and the brain weight of the Negro, whether pure or mixed with white races, tends on the average to be smaller than the same dimensions in whites. The amount of precise data upon which this opinion rests is, however, meager. In 1849 Morton[3] published a series of observations on the cranial capacity of various races, using the method described in his "Crania Americana," which substituted "leaden shot" one eighth inch in diameter for the conventional mustard or millet seed. He gives no distributions, but tables (in cubic inches) the minimum and maximum observations and the means for some 20 racial groups, of which four are negroid. Seventy-four skulls of "Native African family" and "American-born Negroes" (62 of the former and 12 of the latter) gave a combined mean cranial capacity of 1,360.1 cc,[4] as compared with a mean capacity for 18 German, 5 English and 7 Anglo-American skulls averaged together of 1,489.6 cc. The mean capacity of the Negro skulls was thus 91.3 per cent. of that of the Caucasian group with the largest average capacity. Morton's conclusions and his table were republished elsewhere a year after their original appearance,[5] but without additional data.

[1] From the Department of Biology of the School of Hygiene and Public Health, Johns Hopkins University.

[2] Pearson's laboratory has furnished numerous examples of the value of studying old data by modern methods, notably in a series of papers analyzing Galton's anthropometric data (*cf. Ann. of Eugenics, passim*). Greenwood's (*Biometrika*, III, 63–83, 1904; IX, 473–485, 1913) analysis of autopsy records is another case in point.

[3] S. G. Morton, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 4, pp. 221–224, 1849.

[4] The original figures are in cubic inches. I have here and elsewhere in the paper when necessary translated dimensions in English units to metric units for the sake of uniformity.

[5] S. G. Morton, *Trans. Amer. Med. Assoc.*, Vol. 3, pp. 56–58, 1850.

Peacock (*loc. cit. infra,* p. 523) measured the cranial capacity of all the skulls of "ascertained race" in the museum of St. Thomas's Hospital, by the millet seed technique. For 9 Negro skulls the mean capacity was 1,295 cc, as compared with 1,465 cc for 16 skulls of "Europeans," all being males in both cases. The Negro mean is 88.4 per cent. of the "European."

Duckworth[6] gives (p. 472) the cranial capacity of his racial Group II (African) as 1,388 cc, while for his racial Group IV (Eurasian—distributed over the continents of "Europe, Asia, and a large part of America") the cranial capacity is (p. 475) about 1,500 cc, the former capacity being thus 92.5 per cent. of the latter. This is in substantial agreement with the percentage from Morton's data.

In 1865 Peacock[7] published two papers (the second an appendix to the first) on the actual weight of the brain of the Negro instead of its inferred size from the cranial capacity. He actually weighed 5 brains, and copied from John Reid's tables the weights of two others. Of the five males three died of phthisis and were greatly emaciated. The mean weight of the entire encephalon for these five was, by my computation, 1,256.8 gm. Peacock was able to cite from the literature at the time he wrote, but four other actually observed Negro brain weights, one made by Tiedemann (*Phil. Trans.,* 1836) two by Soemmering and one by Sir Astley Cooper.

Waldeyer[8] in 1894 gave as the mean weight of 12 male native African Negro brains, weighed fresh in 11 of the 12 cases, 1,148 gm. But this low mean is probably partly to be accounted for by the facts that; (a) 2 individuals were only 15 years old, (at which age the growth of the brain can hardly be complete), and (b) several of the individuals had died of wasting diseases and were greatly emaciated. Waldeyer quotes (p. 1220) from the 1885 edition of Topinard's *Anthropologie générale* a mean weight of 1,234 gm for 29 male Negro brain weights collected from the literature, and based upon a very heterogeneous lot of individuals.

Bean[9] in 1927 reported the brain weight of Negro males as smaller than that of white males, the difference being larger relatively than in respect of either liver, kidneys, spleen, heart, appendix or pancreas. His conclusions were derived from 117 autopsies.

Vint[10] gives the most recent figures on Negro brain weights. He finds (p. 217): "In a series of 389 apparently normal adult male native [Kenya natives chiefly of Bantu and Nilotic stocks] brains, the average weight was 1,276 gm or 45 oz., the extremes being 1,006 gm and 1,644 gm." He figures the average skull capacity to be 1,230 cc. These figures agree reasonably well with Peacock's quoted above. Vint, on the basis of a not too sound general European white mean brain weight, finds that the native African brain is 10.6 per cent. lighter.

Next to Vint's the longest series of Negro brain weights apparently ever recorded was collected in a series of over 400 autopsies made during the Civil War by Surgeon Ira Russell, of the 11th Massachusetts Volunteers. His data were discussed by Hunt,[11] in a report to the U. S. Sanitary Commission, that was reprinted in the *Journal of the Anthropological Society of London,* where I first came upon them. The report, in spite of containing some unimportant and easily detectable slips in addition (probably due to bad proofreading)[12] has the great merit of providing frequency distributions for the different groups treated. The class units are somewhat broader than might be desired, but still there are distributions. Hunt's (Russell's) averages are occasionally quoted in anthropological literature, but the data have never been subjected to modern biometrical treatment. It is the purpose of this paper to present the results of such treatment.

The subjects upon whom the autopsies were made, and from which the brain weight data were obtained, were enlisted soldiers. While no specific statement as to age is made, the presumption is that they were young adults, probably mostly in the twenties. Regarding the causes of death the following is quoted by Hunt from Dr. Russell's report on colored hospitals (p. 47):

> From the records of five hundred autopsies[13] (four hundred and seventy-two of which were colored men) made at Benton Barracks, Mo.; Wilson Hospital, Nashville, Tenn.; and L'Ouverture Hospital, Alexandria, Va., it appears that pneumonia and pleuro-pneumonia were found to exist, and were usually the cause of death, in four hundred and six out of the four hundred and seventy-two cases. Tuberculosis existed in thirty-seven cases only. All other diseases eight cases. [Something is plainly wrong with the adding or subtracting here, but

[6] W. L. H. Duckworth, "Morphology and Anthropology." *Cambridge* (Univ. Press), 1904. Pp. xxviii + 564.

[7] T. B. Peacock, *Mem. Anthrop. Soc. London,* Vol. 1, pp. 65–71, 1865 (read Feb. 16, 1864); *ibid.,* pp. 520–524, 1865.

[8] W. Waldeyer, *Sitzungsber. d. k. Preuss. Akad. d. Wiss. Berlin,* Jahrg. 1894, pp. 1213–1221.

[9] R. B. Bean, *Anat. Rec.,* Vol. 11, Jan., 1917.

[10] F. W. Vint, *Jour. of Anat.,* Vol. 48, pp. 216–223, Pl. I–III, 1934.

[11] S. B. Hunt, *Jour. Anthrop. Soc. London,* Vol. 7, pp. 40–54, 1869.

[12] These slips were promptly pointed out by J. Barnard Davis (*Jour. Anthrop. Soc. London,* Vol. 7, pp. 190–192, 1869), who also with justice criticized points in Hunt's somewhat exuberant deductions about the Negro generally.

[13] Hunt specifically states (pp. 51–52) that the brain weight data came from this particular series of autopsies.

TABLE I

BIOMETRIC CONSTANTS FOR BRAIN WEIGHT, COMPUTED FROM DATA GIVEN BY HUNT

Race	N	Mean (grams)	Median (grams)	Standard deviation (grams)	Coefficient of variation (per cent.)	Minimum observation (grams)	Maximum observation (grams)	Range (grams)
White	24	1470.6 ± 16.2	1469.0 ± 20.1	118.0 ± 11.6	8.02 ± .79	1254.5	1814.4	559.9
/4 White	25	1409.0 ± 14.5	1399.8 ± 18.1	106.4 ± 10.2	7.56 ± .73	1134.0	1729.3	595.3
/2 White	47	1355.7 ± 11.6	1354.1 ± 14.5	118.6 ± 8.2	8.75 ± .61	1070.2	1615.9	545.7
/4 White	51	1321.6 ± 12.8	1330.5 ± 15.9	136.3 ± 9.1	10.31 ± .70	1091.5	1672.6	581.1
/8 White	95	1315.3 ± 7.9	1328.2 ± 9.9	116.7 ± 5.7	8.88 ± .44	978.1	1615.9	637.8
/16 White	22	1307.9 ± 12.8	1304.1 ± 15.8	88.3 ± 9.1	6.75 ± .69	1134.0	1431.7	297.7
ll mixtures together	240	1333.6 ± 5.4	1338.4 ± 6.8	122.1 ± 3.7	9.15 ± .28	978.1	1729.3	751.2
lack	139	1354.8 ± 6.8	1354.9 ± 8.5	120.2 ± 4.8	8.87 ± .36	1013.5	1587.6	574.1

appears tolerably clear that the great majority of the olored men died of pneumonia.]

The biometric constants are given in Table I. The ifferentiation of the mixed bloods, as given in the able, was presumably based solely upon casual judgment from skin color and not from either genealogies (as in the work of Herskovitz[14]) or measurement of pigmentation. But it is important to note that in ny event, these are *American* Negroes, not native Africans, and even by the time of the Civil War there ad been a very considerable amount of intercrossing, o that absolute purity of Negro ancestry could be sserted in any particular case (regardless of depth of skin color) only with a certain reserve and caution.

From Table I the following points may be noted.

(1) The mean for the black group is about 207 gm greater than Waldeyer's figure for native African Negroes, but only 78.8 gm greater than Vint's. I have already given reasons for thinking Waldeyer's mean abnormally low. Considering that in all probability there was some white blood in Hunt's "black" group, and allowing for other racial and environmental differences certainly existing as between the two samples, the agreement of the present mean with Vint's seems quite a reasonable one.

(2) The accuracy and general reliability of Russell's brain weighings is attested by the following pertinent facts: (a) in no instance is there a significant difference between mean and median in his data, indicating the absence of significant skewness in the distributions. It has been shown[15] that brain weight distributions from the most reliable data are characteristically symmetrical. (b) The coefficients of variation in the present series have values not far from 8 per cent. This has again been shown (Pearl, *loc. cit.*) to be the characteristic figure for brain weight variability in large and accurately weighed samples.

(3) The mean brain weight for the black series is 92.1 per cent. of that for the white series. The approximate agreement of this with Morton's, Peacock's, Duckworth's and Vint's results is clear, and may reasonably be taken to lead to the conclusion that the Negro brain is, on the average, from 8 to 10 per cent. lighter than the fairly comparable white brain.

(4) The brain weights for the Negro-white mixtures are extremely interesting in the smooth decline of the means with a putative increase in Negro blood in the mixture (based presumably, however, solely on casual judgment of skin color). The smoothness of the figures has enticed me into struggling to rationalize them genetically, but I have had no success, finding myself in this respect in precisely the same position as Herskovitz (*loc. cit.*) and his student Barnes when confronted with a similar problem. Perhaps some ingenious reader can do better. It will be noted that mean brain weights for the whites (0 per cent.), ¾ whites (25 per cent.) and ½ whites (50 per cent. Negro blood) lie, if plotted, very close indeed to a straight line. So also do the means for the ¼, ⅛ and 1/16 whites. But the line fitting the latter three groups has a different (less marked) slope downwards than the former. And finally the mean for the black group (putatively pure Negroes) is almost identical with that for the ½ whites. Reasons have already been given for believing the actual weighings to be substantially accurate.

(5) The mean brain weight of the "All mixtures together" group is lower than that for the "black" group, and necessarily still farther below that for the whites. The mid-point between the white and "black" means is 1,412.7 gm. The mean for no single mixed

[14] M. J. Herskovitz, "The Anthropometry of the American Negro." New York, (Columbia Univ. Press) 1930. Pp. xvi + 283.

[15] R. Pearl, *Biometrika*, Vol. 4, pp. 13–104, 1905.

group is as great as this figure, the nearest being the "¾ white" mean.

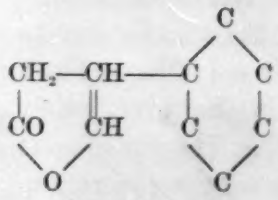
(6) The relative variability of the Negro brain weight (as measured by the coefficient of variation) appears to be slightly greater than that in the whites, though the difference can not be asserted to be significantly greater than might arise from fluctuations of random sampling, so far as concerns any of the comparisons that can be instituted on the basis of the present material.

RAYMOND PEARL

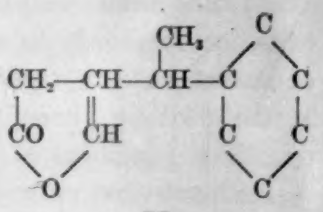
THE DIGITALIS GLUCOSIDES. VIII. THE DEGRADATION OF THE LACTONE SIDE CHAIN OF DIGITOXIGENIN

DEGRADATION studies with a number of derivatives of strophanthidin and of the digitalis aglucones have been in progress since the reports of our earlier work.[1] Because of the possible significance of recent results which we have obtained, in particular in degradation experiments with the digitalis aglucones, we wish to present a preliminary report of this phase of the work before its completed presentation can be made elsewhere.

Our previous observations have suggested that the unsaturated lactone side chain of the cardiac aglucones may be attached directly on the β-carbon atom to a six-membered ring as in formula I, or by an intermediate carbon atom as in formula II.[2] The latter



I



II

possibility, however, would be excluded if the presence of the sterol ring system as indicated by the formation of methyl cyclopentanophenanthrene on dehydrogenation of strophanthidin[3] could be substantiated by other means. For further information we have attempted the graded degradation of the lactone side chain in a number of selected substances. The present preliminary report deals with the experience with a previously described digitoxigenin derivative, γ-digitoxanoldiacid.[4] On oxidation of its secondary hydroxyl group with chromic acid this was converted into the keto acid, *digitoxanondiacid*, $C_{23}H_{34}O_5$. On reduction by the Clemmensen method, *digitoxandiacid*, $C_{23}H_{36}O_4$, resulted. The *dimethyl ester* was converted with Grignard reagent into the bis-diphenyl carbinol which on oxidation with chromic acid was degraded with the loss of three of the original carbon atoms of the lactone side chain to the *monobasic acid*, $C_{20}H_{32}O_2$.

At this point the striking property of this acid of forming very sparingly soluble salts which made manipulation somewhat difficult recalled a similar experience reported by Wieland, Schlichting and Jacobi in the case of aetiocholanic acid of the same formula. On further study other resemblances appeared. Our acid melted at 219–219.5°. The melting point given for aetiocholanic acid is 219°. The methyl ester of our acid melted at 97–98°. Wieland, Schlichting and Jacobi reported 98–99° for aetiocholanic methyl ester. The ethyl ester of our acid melted at 76.5–77.5°. Aetiocholanic ethyl ester melts at 78–79°.

The striking similarity of the two series of substances thus suggests the possible identity of our degradation product from digitoxigenin with aetiocholanic acid. Final check of such identity, however, must await the results of a direct comparison of physical constants, mixed melting points, etc. We are attempting to procure the material for such comparison.

Should the identity of these substances be verified, the conclusions are obvious which can be drawn in regard to the structure of the cardiac aglucones.

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[1] W. A. Jacobs and R. C. Elderfield, *Jour. Biol. Chem.*, 102: 237, 1933.

[2] W. A. Jacobs and R. C. Elderfield, *Jour. Biol. Chem.*, 100: 676, 1933; R. C. Elderfield and A. Rothen, *Jour. Biol. Chem.*, 106: 71, 1934.

[3] R. C. Elderfield and W. A. Jacobs, SCIENCE, 79: 279, 1934.

[4] W. A. Jacobs and E. L. Gustus, *Jour. Biol. Chem.*, 86: 211, 1930.

[5] *Zeits. physiol. Chem.*, 161: 102, 1926.

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